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REFRIGERATION SYSTEM INCLUDING RECEIVER

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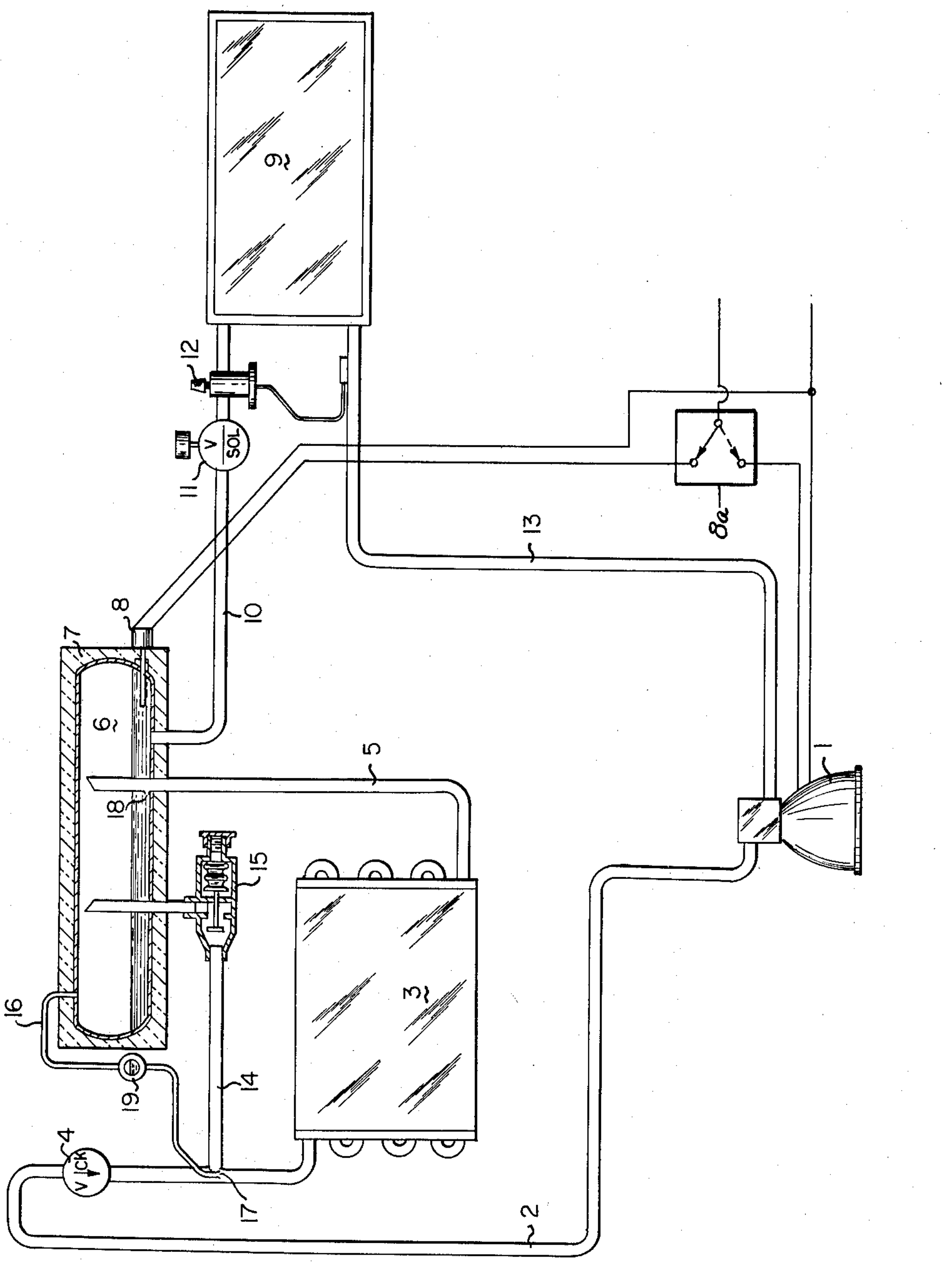

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REFRIGERATION SYSTEM INCLUDING RECEIVER

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My invention relates to refrigeration systems and particularly to refrigeration systems using an air cooled or an evaporatively cooled outdoor condenser. It may be applied to many types of refrigeration, air conditioning and heat pump systems.

This application is a continuation-in-part of my copending application Ser. No. 132,025, now abandoned, filed August 17, 1961.

A mechanical refrigeration cycle commonly comprises a compressor, a condenser, a receiver or accumulator tank, an expansion device and an evaporator, interconnected in series sequence by suitable piping. My invention uses the same basic components. The principal difference lies in the location of the receiver in relation to the condenser. In conventional systems the condenser is located in elevated relationship to the receiver, so that as the refrigerant vapor is liquified in the condenser it may drain by gravity into the receiver. The receiver also acts as a surge tank which compensates for fluctuations in refrigerant requirements in other parts of the system. It is usually sized sufficiently large as to store the entire refrigerant charge of the system, so as to permit pump out of other components for repairs. In my invention I have elevated the receiver to a position above the topmost tube of the condenser, so that gravity flow of refrigerant liquid is reversed. It is this novel feature which is the basis of my invention; the advantages of which shall become apparent as I explain the use and operation.

Many installations of refrigeration and air conditioning must operate the year around. Cold storage rooms, refrigerated display cases, laboratory rooms, farm bulk milk storages, processes for industry, transportation refrigeration and air conditioning, and buildings with internal heat sources are representative of applications where cooling may be required even in mid-winter.

Because of the definite temperature-pressure relationship of confined refrigerants, when the air temperature at the condenser falls, the condensing pressure also falls, frequently lowering the refrigerant pressure below that required for proper operation of expansion devices. This causes a reduction in evaporator capacity. At the same time, low condensing pressure also causes a considerable increase in compressor capacity. This combination of lowered evaporator capacity and increased compressor capacity causes a highly unbalanced system operation, which results in off-on cycling of the compressor and promotes rapid wear of controls, motors and starters. It also promotes oil dilution with refrigerant, oil pumping by the compressor due to rapid fluctuations in crankcase pressure, and sometimes even compressor damage. It is one object of my invention to provide a system including an improved method of condensing pressure stabilization during conditions of low ambient air temperature at the condenser.

There are other reasons why condensing pressure stabilization is a desirable feature. When hot gas defrosting systems are used, rapid defrosting depends largely upon a sufficiently high discharge pressure. When compressor capacity-reduction controls are used, the condenser becomes greatly oversized in capacity in relation to the reduced output of the compressor during reduced-capacity operation. In systems employing capillary tube, restrictor-type expansion devices, which are particularly

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critical of pressure variances, this feature is quite important.

There are several commercial systems of pressure stabilization on the market, none of which employs the principle of my invention. None of these systems can provide immediate response; they rely upon systems of on-off fan control or of dampering the air flow or of restriction of refrigerant flow from the condenser to the receiver. In every case, control is not possible until after considerable refrigerant has been condensed. It will become apparent that my invention provides immediate control, which represents an improvement over existing methods of discharge pressure stabilization.

When a refrigeration system shuts off, the refrigerant tends to migrate from warmer parts to the coldest point of the system. In cold weather, this point is the condenser. In severely cold weather, so much refrigerant may migrate to the cold condenser that the pressure remaining in the system is insufficient to operate pressure and safety controls to permit the compressor to start again. Sometimes the compressor may start, then almost immediately shut off again and remain off. Another feature of my invention is the complete and positive prevention of refrigerant migration to the condenser during the off cycle.

Perhaps the most important feature of my invention is the ability to maintain sufficient pressure during shut down to actuate the controls for starting and to assure operation until normal system pressures prevail. To illustrate the principle of this feature of my invention, let us assume we have two enclosed pressure tanks, one above the other, with several tubes connected between the tanks to permit unrestricted communication of the contents of the tanks. Let us completely fill the lower tank and the communicating lines with liquid refrigerant, plus enough additional to provide a level within the upper tank. The balance of the upper tank is filled with refrigerant vapor. Pressure and temperature should now be essentially the same for both vessels. Now, let us warm the upper vessel. Due to the definite temperature-pressure relationship of confined refrigerants, the temperature and the pressure of the upper vessel increase. However, only the pressure increases in the lower vessel; the temperature is unaffected. Also, there is no tendency for flow of the liquid refrigerant between vessels since heated liquids rise and it is the liquid in the upper vessel which has been heated.

If we apply this principle to the condenser and receiver of a refrigeration system, making the condenser the lower vessel and the receiver the upper vessel, it becomes evident that the receiver may be heated without affecting the temperature of the condenser, yet the pressure increase due to heating the receiver will be reflected throughout the entire condensing system. For economy, the receiver must be insulated to reduce heat loss, so that only a small heat source will be required to maintain system pressure during the off cycle of the compressor. It is interesting to note that the temperature of the air surrounding the condenser does not influence the pressure retained in the circuit. This features makes it practical to use the same fan for several condenser circuits, yet retain full starting ability and condensing pressure control on each circuit, independently. It also permits roof mounting of the condenser and receiver, which has been avoided heretofore where cold weather operation was required. My invention assures correct system starting and operating pressures regardless of where it is used, for any application, and under any ambient air temperature normally to be encountered.

Still another feature of my system is that it is relatively easy for the installer to determine the correct refrigerant charge for the system. A major complaint of other methods of winter control is that there is no practical way to determine when the proper amount of refrigerant has been installed. A refrigerant shortage can not be determined except during the coldest weather; an overcharge will reduce the condenser capacity in summer. With other winter systems, the level within the receiver varies according to the weather. Because my receiver tank is located above the condenser, the level of refrigerant may actually be seen through an auspiciously located gauge glass. Upon system shut-down, the liquid level always settles to the same level, winter or summer.

In the accompanying drawing I have illustrated schematically a refrigerating system embodying my invention, but it is to be understood that I am not limited to the specific details thereof, which may be varied without departing from the basic principles of my invention.

With reference to the drawing, a compressor is indicated at 1 and from this compressor a hot gas discharge line 2 leads to a condenser coil 3 which is air or evaporatively cooled. The line 2 is provided with a check valve 4. The condenser drain is connected by a line 5 to a liquid receiver and storage tank 6 which is a closed vessel. An important feature of my invention is that the receiver 6 is located at a higher elevation than the condenser 3 so that when the system is shut down, the liquid refrigerant in the receiver flows by gravity to fill the condenser coil 3. The drawing shows the system in the off condition.

The receiver 6 may be provided with an insulating jacket 7 and an artificial heat source such as an immersion type electric heater 8. The jacket and heater would be used for applications where the condenser ambient temperature may be near or below the temperature of the evaporator indicated at 9. The receiver 6 is connected to the evaporator 9 by a liquid refrigerant line 10 which is provided with a solenoid control valve 11 and an expansion valve 12. The expension valve 12 is controlled by a standard pressure bulb as indicated. The evaporator 9 is connected by a line 13 to the compressor 1 suction inlet.

A by-pass line 14 connects between the line 2 and the receiver 6 and is provided with a control valve 15. This control valve 15 is a pressure-actuated type, closing on pressure increase, and adjustable for operation at a selected pressure. An equalizing line 16 connects between receiver 6 and line 2, terminating within line 2 with an orifice 17.

An important feature of this system is the location of the receiver 6 in elevated relationship to condenser coil 3, combined with the control valve 15 arranged to permit discharge gas by-pass of the condenser coil 3 directly to the receiver 6. The control valve 15 varies the capacity of the condenser 3 by controlling the flooding of the condenser coil 3 with liquid refrigerant in an infinite number of graduations, thus varying the amount of effective heat transfer surface of the coil 3 and maintaining a constant condensing pressure regardless of ambient temperature.

When the system is shut down, most of the liquid refrigerant in the receiver 6 flows by gravity to fill the condenser coil 3. Condenser coil 3 is completely inactivated. Upon start-up, the discharge gas from compressor 1 is diverted through the open control valve 15 directly to the receiver tank 6 and the condenser coil 3 remains inactivated. Since little condensing takes place, the pressure begins to rise immediately, thereby assuring prompt and adequate liquid pressure at the expansion valve 12 for evaporator 9 operation.

As the pressure increases to the setting of the control valve 15, the valve 15 modulates toward the closed position, thereby restricting gas flow through line 14 and forcing the discharge gas to flow to the condenser coil 3. This forces liquid from the condenser outlet into the receiver 6 through line 5. The discharge gas entering the condenser coil 3 begins to condense, according to the surface exposed at the particular valve 15 opening. Further pressure increase causes the valve 15 to close farther, eventually reaching full closed position, thus directing all

gas flow to the condenser 3 and forcing all excess liquid refrigerant from the condenser 3 to the receiver 6. This allows the condenser 3 to function at its fullest capacity. Upon a pressure drop the reverse action results, with control valve 15 seeking to maintain pressure stabilization of the high pressure side of the system.

The equalizer line 16 is provided to permit escape of gaseous refrigerant from the receiver 6 after control valve 15 closes fully. This line 16 is extended from the upper portion of receiver 6 into line 2 and terminates in a flow orifice 17 therein. As the discharge gas flows rapidly through line 2, it passes orifice 17 and a reduction in pressure is induced in line 16 and is communicated to the receiver tank 6. In this manner, gas binding of the receiver 6 is prevented. A liquid indicating sight glass 19 may be installed in line 16 at an appropriate level to indicate correct refrigerant charge for the system. After normal shut-down, the correct level would show as a meniscus line within sight glass 19.

Line 5 from the condenser 3 to receiver 6 extends as an open end standpipe into receiver 6. Within receiver 6, an orifice 18 is located in this standpipe near the bottom of receiver 6. This arrangement permits uninterrupted flow of liquid refrigerant through line 5 into receiver 6, but retards the reverse flow of liquid refrigerant from receiver 6 to condenser coil 3 during shut-down. This retardation of reversed flow, in combination with the induction effect produced by orifice 17, permits pump-out of refrigerant into condenser 3 and receiver 6 so that repairs may be made to other components of the system. Normal pump-out operations require short sequences of compressor operation.

As indicated, for applications where the condenser ambient temperature may be near or below the temperature at the evaporator 9, the receiver 6 may be insulated as needed to reduce heat loss and an artificial source of heat (such as an immersion heater 8) supplies heat to the receiver 6 during the system off cycle. A suitable circuit including a control switch *8a* is shown in the drawing for controlling the heater 8. When the switch is in one position, indicated by full lines, the heater is on and the compressor is off. When in the other position, as indicated by dotted lines, the heater is off and the compressor is on. The refrigerant in the receiver 6 is increased in both temperature and pressure by heat. The balance of the refrigerant in the high pressure circuit is contained between the check valve 4 and the liquid line solenoid valve 11 and reflects the same pressure as that in receiver 6, although the temperature may be considerably lower. There is no convection of heat since heat rises and the receiver 6 is higher than condenser 3. Migration of refrigerant to the cold condenser cannot occur since the condenser 3 has already been filled by gravity with liquid refrigerant. Since there is neither migration nor convection of heat nor condensing immediately upon start-up, only a small amount of artificial heat is required to maintain adequate pressure for starting the system by normal pressure control, regardless of condenser ambient temperature.

I have shown from the above that my invention provides a refrigerating system having many advantages which have been discussed and others which will be apparent.

Having thus described my invention, what I claim is:

1. A refrigeration system comprising a compressor, a condenser connected to the hot gas discharge side of the compressor, a liquid receiver connected to the condenser, said liquid receiver being located at a level higher than the condenser so as to fill the condenser with liquid therefrom by gravity when the compressor is not running, an evaporator connected by a line to the inlet side of the compressor, a by-pass line connected between the hot gas discharge side of the compressor and the receiver having a normally open control valve to permit hot gas to by-pass the condenser, said by-pass line having an

equalizer tube connected thereto for by-passing said control valve.

2. A refrigeration system according to claim 1 in which the control valve is connected by a portion of the by-pass line to the receiver which is in the form of a tube extending upwardly into the receiver to a suitable level above the bottom thereof.

3. A refrigerating system charged with refrigerant and comprising a compressor having an on and off cycle and a hot gas discharge line, a condenser connected to the hot gas discharge line, a receiver for liquid refrigerant, an evaporator connected to the receiver by a connection including an expansion means and connected to the suction side of the compressor, said receiver being located entirely above the condenser and being connected thereto by interconnecting lines, said charge of refrigerant in the system under liquid conditions being greater in volume than the volume of the condenser and interconnecting lines with the receiver so that the condenser and interconnecting lines are filled completely by gravity with liquid refrigerant during the off cycle of the compressor and a level of liquid remains in the receiver during the off cycle thereby rendering the condenser ineffective upon start-up until said liquid in said condenser has been displaced by gas entering through said discharge line, and means for heating the receiver during the off cycle of the compressor to maintain sufficient pressure therein.

4. A refrigerating system according to claim 3 including check-valve means in said discharge line to prevent liquid refrigerant flow from said condenser to said compressor.

5. A refrigerating system according to claim 3 including a by-pass line connected between the compressor discharge line and the receiver, a control valve disposed in the by-pass line, said control valve closing in response to receiver pressure.

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